

Evaluation of Performance
and Cost-Effectiveness
of Thin Surface Treatments

Progress Report #1

Oregon HPR Project 087-5169

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16. Abstract This is the initial report for a study to determine the long term performance and life cycle costs for thin surface treatments. For this study a thin surface treatment is defined as less than 2 inches. A total of 89 projects constructed during 1984, 1985 and 1986 were selected for monitoring. Thin overlays, chip seals, chip seals with polymer modified asphalt, oil mats, and cold recycling sections were the major categories included in this study. This report classifies the projects by type, location and year of construction; summarizes construction costs; outlines the evaluation criteria and methods; and lists the early rating results. Insufficient time has passed to detect any trends or reach any conclusions.			
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DISCLAIMER

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INTRODUCTION

As Oregon road system ages, emphasis moves from the new construction to preservation and maintenance of the road surfaces. In the recent past, besides the everyday road patching, the thick (over 2") overlays became the main asphalt pavement surface management tool. Recently some of the new and reinvented techniques that encompass the thin surface treatments gained in popularity. Unfortunately there are no hard facts available on the longevity and useful life cycle of these treatments.

To develop the kind of hard data that will assist engineers in deciding on an economical application of a thin surface treatment is the main purpose of this study. Additional useful information might be developed along the way. For example we might find that chip sealing is not a good application on the coast or cold recycling is not suitable on high traffic loaded roads, etc.

This project is investigating long term performance and economy of thin surface road treatments installed on asphalt pavements. Real life road projects that were installed as part of construction and maintenance program are inspected and evaluated annually. Each road project is viewed as a whole and also in detail. A detailed review is done by selecting a 250 ft section to study intensively. Only those treatments 2" or thinner are considered for this project. Each site will be followed until it reaches the end of its useful life (defined later). Comparative life cycles and costs will be developed based on the field findings.

To assure that this was a unique project and similar study was not done elsewhere, Highway Research Information Service (HRIS) literature search was made. The search confirmed that at that time there was no similar research conducted.

SITE SELECTION

This project identified 98 possible test sites during the 3 year construction period. In 1984, 48 sites were chosen. This was followed in 1985 by 39 more sites, and finally in 1986, 11 more were added. The sites in the first 2 years were selected for various treatments; last year, only cold recycling jobs were added. Later, nine sites were deleted from the study, mostly due to construction changes which no longer qualified them as thin surface locations. The study covers all geographical and climatic regions of Oregon. The selected sites have the following treatments:

- a. 5 sites "B" type A.C. - one with seal
- b. 15 sites "C" type A.C. - one with seal, one over geotextile
- c. 6 sites "E" type A.C. with seal
- d. 3 sites "F" type A.C. with seal
- e. 2 sites emulsified A.C. with seal
- f. 15 sites chip seal
- g. 15 sites polymer modified chip seal - with Styrelf
- h. 10 sites oil mats
- i. 2 sites large patching
- j. 15 sites cold recycle - most with seal
- k. 1 site sand seal

The asphalt concretes B, C, E, and F listed above are standard Oregon plant hot mixes:

- B: dense graded, 3/4 in. minus aggregate
- C: dense graded, 1/2 in. minus aggregate
- E: open graded, 1/2 in.- #10 aggregate
- F: open graded, 3/4 in. - #10 aggregate

Emulsified asphalt concrete is an open graded plant mix using emulsion for binder and 3/4 in. maximum aggregate.

Monitoring of two sites was terminated when they reached the end of their useful life. Eighty-seven active sites currently remain. An interesting item is that the costs within each group of treatments are relatively close.

Of the two terminated chip seal sites, one had considerable construction problems, the other had some construction problems and high 18 kip Equivalent Axle Loads (EAL).

Additional details describing site and treatment distribution are included in Appendix B.

DATA COLLECTION

Historical Data Collection

Miscellaneous information related to each test site location and its history was collected. This includes, but is not limited to:

- a. Section location
 - Highway and route number
 - Beginning and end milepost of treatment
 - Beginning milepost of 250 ft intensive study section
- b. Surface treatment type
- c. Climatic region
- d. Previous pavement type
- e. 18 kip Equivalent Axle Load (EAL)
- f. Contract number if work was by contract

Pre-Construction Survey

A "windshield survey" was conducted to assess the surface condition for each site. Within each site a detailed evaluation was made of a 250 ft intensive study section. This evaluation included pavement distress, Dynaflect deflection measurements for most sites (this provides data on subgrade and pavement strength), drainage condition, surface type, and representative photographs.

Construction Data

Information was gathered via field questionnaires and from Construction Section files on:

- a. Asphalt content
- b. Asphalt type
- c. Aggregate gradation
- d. Ambient air and asphalt placement temperatures
- e. Weather and rainfall
- f. Problems encountered
- g. Type of equipment used
- h. Paving costs in \$/sq. yd.

Post-Construction Survey

In the fall after each construction season, all new test sites were inspected and evaluated as described in the Annual Performance Evaluation.

Annual Performance Evaluation

The following are done yearly, mostly in late spring:

- a. Windshield survey and rating of whole site are performed. Sites are rated using the Oregon road surface rating system: very good, good, fair, poor, very poor. A detailed definition of this system is attached as Appendix A.
- b. Distress indicators (cracking, potholes, ravelling, etc.) are surveyed in the 250 ft intensive study section, using the "Highway Pavement Distress Identification Manual, DOT-FH-11-9175, March 1979, USDOT/FHWA" as a scale for the description and tracking of individual distresses.
- c. Maintenance costs are assessed.
- d. Dynaflect deflections are taken. Ideally, in addition to pre and post-construction readings, one reading will be taken sometime during the pavements useful life and another at the end of its useful life. Useful life is defined as time from construction until one of the following conditions is reached:
 1. The Seal is gone (where seal is the total treatment);
 2. Surface is poor or very poor as defined by the Oregon method described above; or
 3. Extensive repairs are in place.

The Dynaflect data will be processed by computer to indicate strength of pavement and subgrade. This data will be compared to the pre-construction Dynaflect analysis.

- e. Representative photographs are taken.
- f. Ride quality testing is performed on selected sites as equipment becomes available.

Data Availability

Most of the data, some of it simplified, is kept on microcomputer discs using Data Base III+ software. The computer is programmed to retrieve data in several different categories; this assists in the discovery of general trends. Presently, the five reports briefly described below are available:

a. Thin Treatment Paving Jobs by Job Number

Data is ordered by job site number. Additional data listed for each site are: cost/sq. yd., treatment, and comments.

b. Thin Treatment Paving Jobs by Treatment

Data is ordered by treatment type. Additional data listed for each site are: job number, cost/sq. yd., and comments.

c. Thin Treatment Paving Jobs by 18 kip EAL

Data is ordered by number of 18 kip Equivalent Axle Loads (EAL) per day. Additional data listed for each site are: job number, treatment, and comments.

d. Thin Treatment Paving Jobs by Cost

Data is ordered by costs in dollars per sq. yd. Additional data listed for each site are: job number, treatment, and comments.

e. Thin Treatment Paving Jobs by Highway Number

Data is ordered by Oregon Highway Number, which can be cross referenced to Interstate, US and Oregon Route Numbers. Additional data listed for each site are: job number, mile post where 250 ft test section begins, Dynaflect test site number, and treatment.

f. Total data listing is available for each site.

CONSTRUCTION COSTS

Construction costs for each site were collected from field questionnaires, Construction Section files for contractor built projects, and Planning Section files for State constructed projects. Only direct paving costs, reduced to dollars/sq yd, for each treatment were used. The average cost for each group of treatments was calculated by adding all unit costs within each treatment and dividing by the number of treatments within each group. Costs are listed below:

<u>Treatment (# of sites)</u>	<u>Average Cost (\$/sq yd)</u>	<u>Range(\$/sq yd)</u>
"B" Type Asphalt Concrete (5)	2.68	2.18 - 3.10
"C" Type Asphalt Concrete (15)	3.26	2.40 - 3.77*
"E" Type Asphalt Concrete (6)	1.77	1.30 - 2.60
"F" Type Asphalt Concrete (3)	2.59	2.32 - 2.97
Emulsified Asphalt Concrete (2)	2.24	1.50 - 2.98
Chip Seal (15)	0.41	0.25 - 0.62
Polymer Modified Chip Seal (15)	1.09	0.66 - 1.88
Oil Mat (10)	1.01	0.56 - 1.12
Large Patching (2)	2.21	0.36 - 4.05
Cold Recycle (15)	1.62	0.75 - 2.20
Sand Seal (1)	0.16	0.16

* One "C" type A.C. project cost was \$6.58/sq yd, but it was a small intensive job on a city street, which brought the cost up.

MAINTENANCE COSTS

To date, there has been no major maintenance or repair work done on these projects. In the future, major maintenance costs will be obtained from the Pavement Management Unit of the Planning Section once a year. Minor maintenance costs will be estimated based on visual inspection during annual site evaluations.

INACTIVE SITES

Two sites were terminated because they reached the end of their useful lives. Most of the failure occurred during Winter; when inspected in the spring, there was enough chip seal left, to consider that it served the road up to that time. The construction summaries and failure descriptions follow:

Site 85.01 Interstate 84, MP 10.1-16.7 Useful Life: 10 mos.

Treatment: Polymer Modified Chip Seal

Rate of Application: 0.32 gal/sq yd emulsion; 24 lbs/sq yd aggregate

Ambient Temperature: 70° - 92°F & low humidity eastbound work
up to 85°F & high humidity & overcast
westbound work

EAL: 2160/day; 648,000/life

Treatment was installed over old, dense asphalt concrete recently patched by maintenance forces. The pavement was dry and clean, so no preparation was required. The eastbound lanes were done August 17 and 18, 1985. While under construction, traffic was allowed through for a short time to relieve severe congestion on the bypass. The westbound lanes were treated August 24 and 25, 1985, and no traffic problems were experienced and traffic was kept off the road through initial curing.

The seal was reported to last through most of November, before starting to fail. Aggregate was lost more rapidly in outside lanes and closer to Portland where traffic was heavier. When the site was inspected in spring 1986, the seal was virtually gone. Because of the pattern of failure observed, it is believed, this site short life is due to higher EAL's.

Site 85.16 US 26, MP 44.4-54.7 Useful Life: 10 mos.

Treatment: Polymer Modified Chip Seal

Rate of Application: 0.31 gal/sq yd emulsion; 28 lbs/sq yd aggregate

Ambient temperature: 65°F and lower

EAL: 222/day; 66,000/life

The treatment was installed over old, dense asphalt concrete recently patched by maintenance forces. Work was started August 19, 1985, with some remedial work performed later. During part of construction, fog rolled in and the temperature dropped to 50°F.

The seal was reported to last through most of November, before starting to fail. When the site was inspected in spring 1986, the seal was virtually gone. It appears high temperature and low humidity are essential to successful chip sealing. Additionally, this project is in the mountains where more chains and studded tires are used.

SUMMARY OF SECTIONS BY RATING STATUS

All Oregon State Highways are rated every other Spring by the Department of Transportation. The data is updated every Fall for improvements that occurred during the construction season and is kept by Planning Section, Pavement Management Unit. All ratings listed below were done in 1986. As such they show two years of service on jobs constructed in 1984, and one year of service for those done in 1985. The 1986 treatments were rated by Research Section one to three months after completion.

<u>Treatment</u>	<u>Very Good</u>	<u>Good</u>	<u>Fair</u>	<u>Poor</u>	<u>Inactive</u>
"B" A.C.	1	3	1		
"C" A.C.	9	5	1		
"E" A.C.		3	3		
"F" A.C.	2	1			
Emulsified A.C.		2			
Chip Seal		9	6		
Styrelf Chip S.		7	6		2
Oil Mat		2	8		
Patching		1		1	
Recycle	1	11	3		
Sand Seal	1				
Total	14	44	28	1	2

SUMMARY OF FINDINGS

As shown in the introduction of this interim report the main aim of the study is to answer two basic questions:

1. How long do thin surface treatments last ?
2. How much do they cost over their useful life ?

Only two sites out of the multitude studied have reached the end of their useful life, so it is too early to predict the life cycle costs or even the useful life itself. To date no additional general trends are emerging.

Some of the treatments at the time of the last inspection have already gone through two winters with flying colors indicating that thin surface treatments at their low cost are a definite alternative to more traditional and more costly thick overlays. The construction costs of all sites have been accumulated. In initial costs the seals are less expensive than overlays; cold recycling is somewhere in between the two.

The first two treatments to fail are Styrelf chip seals, which is not necessarily indicative of the remaining thirteen sites of that treatment.

As additional sites reach the end of their useful life the answers to the two basic questions should slowly emerge. Probably the least expensive treatments will have shortest lives but only time will show.

Note: The tables were converted to bar graphs and are attached as Appendix C.

APPENDIX A

**PLATES 1 THROUGH 5
ILLUSTRATE NON-INTERSTATE
PAVEMENT CONDITION
CATEGORIES**

PLATE 1
CONDITION - VERY GOOD

Pavement structure is stable, with no cracking, no patching, no deformation evident. Roadways in this category are usually fairly new. Riding qualities are excellent. Nothing would improve the roadway at this time.

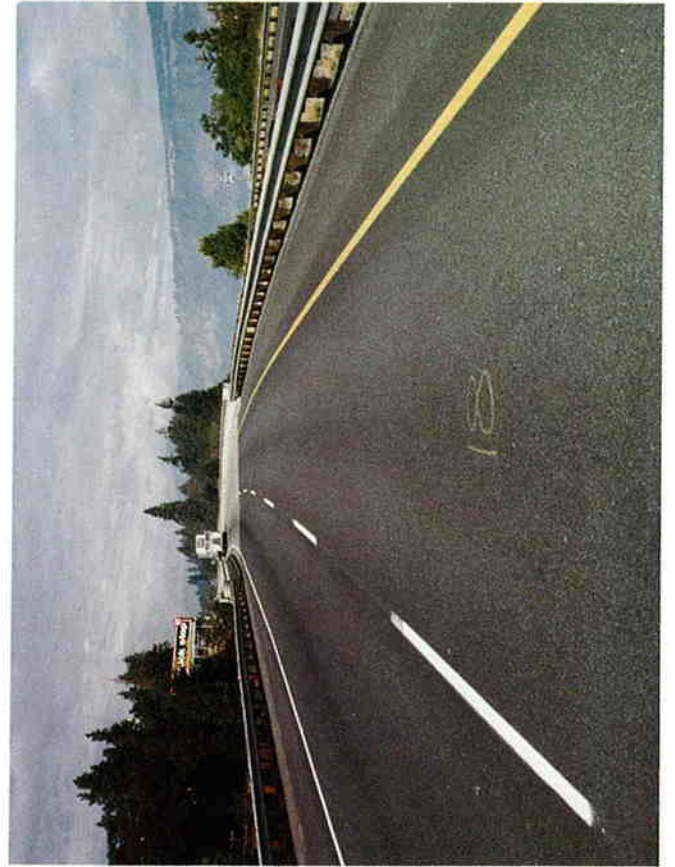
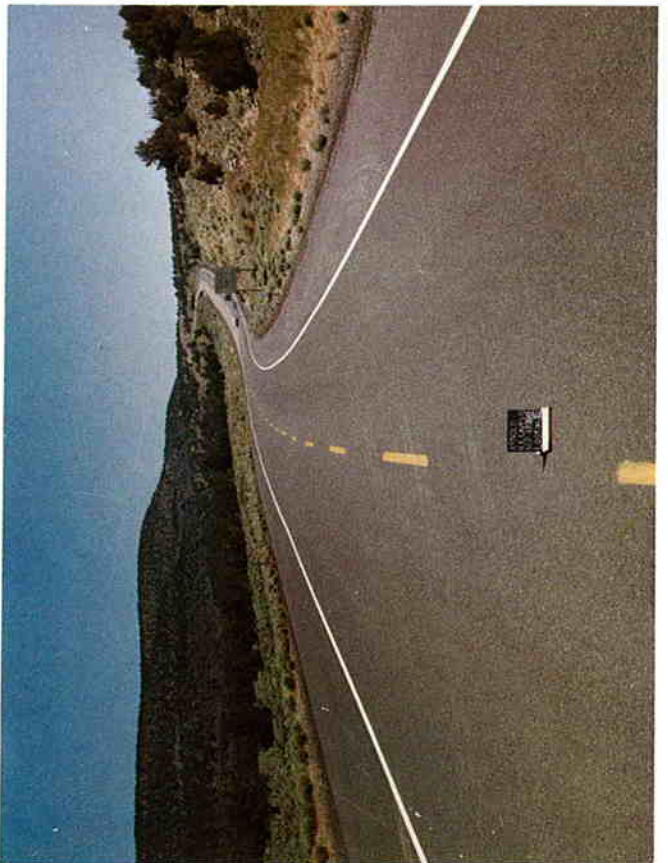


PLATE 2
CONDITION - GOOD

Pavement structure is stable, but may have surface erosion or minor cracking, which is generally hairline and hard to detect, minor patching, and possibly, some minor deformation. Riding qualities are very good. The pavement has a dry or light colored appearance. Some type of rejuvenation of the wearing surface is all that is required.

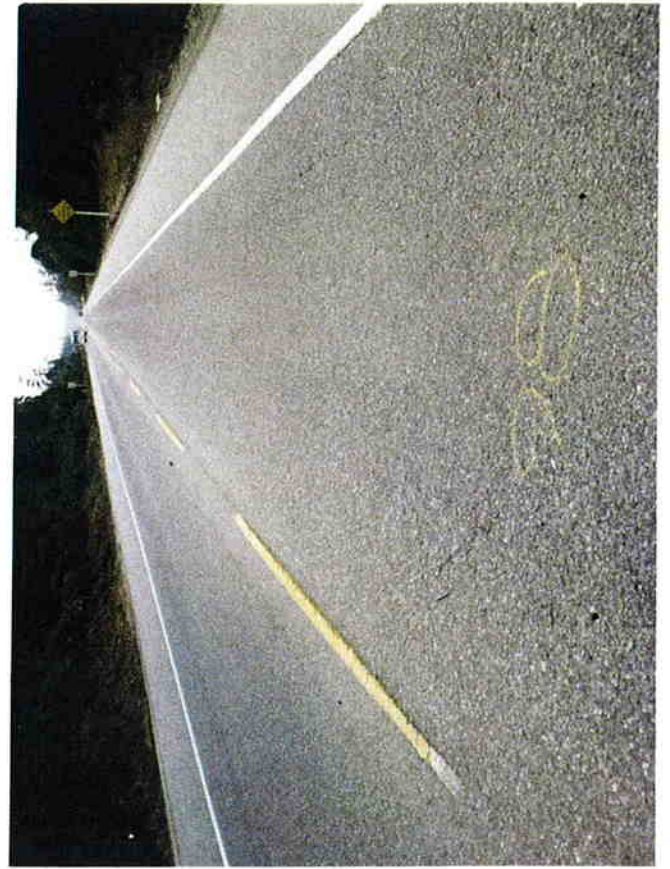


PLATE 3
CONDITION - FAIR

Pavement structure is generally stable with minor areas of structural weakness evident. Cracking is easier to detect. The pavement may be patched but not excessively. Although riding qualities are good, deformation is more pronounced and easily noticed.

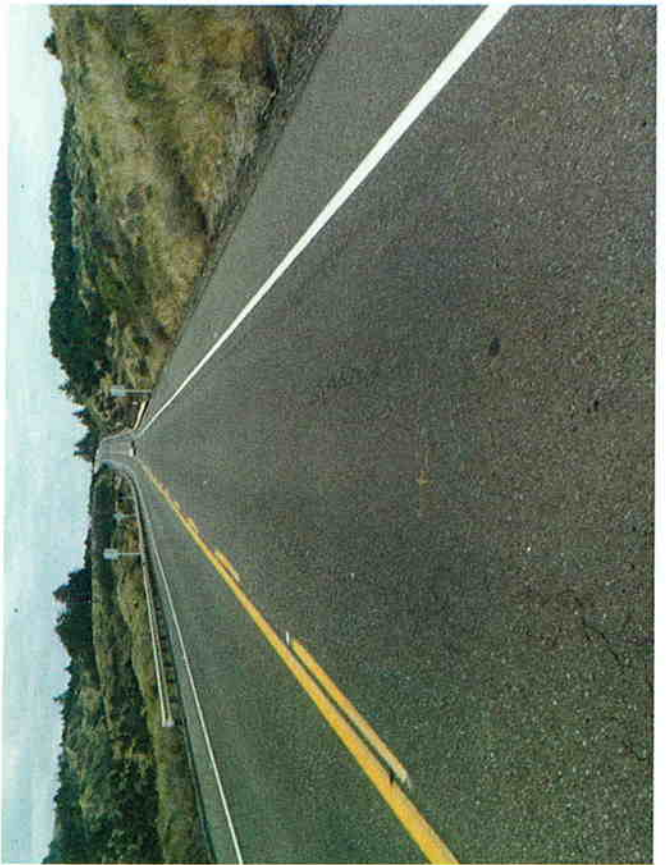


PLATE 4
CONDITION - POOR

Roadway has areas of instability, marked evidence of structural deficiency, large crack patterns (alligatoring), heavy and numerous patches, and very noticeable deformation. Riding qualities range from acceptable to poor. Spot repair of the pavement base may be required.

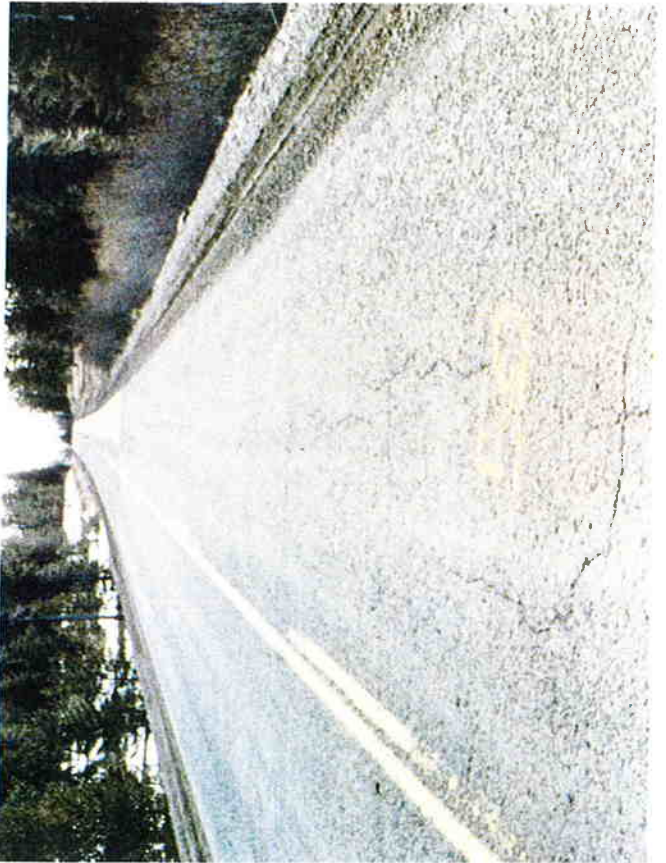


PLATE 5
CONDITION - VERY POOR

Costs of saving the pavement structural section would equal or exceed "complete reconstruction".



APPENDIX "B"

B1

THIN SURFACE TREATMENT PROJECTS BY REGION, TREATMENT & YEAR

1. 1984 THIN PAVEMENT SURFACE TREATMENT PROJECTS

	Asphalt Concrete	Chip Seal	Oil Mat	Recycled A.C.	Blade Patch	Total
Region 1	5	2	0	0	2	9
Region 2	3	5	0	0	0	8
Region 3	4	0	0	0	0	4
Region 4	4	4	0	2	0	10
Region 5	1	5	7	0	0	13
TOTAL	17	16	7	2	2	44

2. 1985 THIN PAVEMENT SURFACE TREATMENT PROJECTS

	Asphalt Concrete	Chip Seal	Oil Mat	Recycled A.C.	Total
Region 1	2	4	0	0	6
Region 2	3	0	0	0	3
Region 3	4	4	0	0	8
Region 4	1	2	0	4	7
Region 5	4	5	3	0	12
TOTAL	14	15	3	4	36

3. 1986 THIN PAVEMENT SURFACE TREATMENT PROJECTS

	Asphalt Concrete	Chip Seal	Oil Mat	Recycled A.C.	Total
Region 1	0	0	0	0	0
Region 2	0	0	0	0	0
Region 3	0	0	0	0	0
Region 4	0	0	0	7	7
Region 5	0	0	0	2	2
TOTAL	0	0	0	9	9

4. 1984, 1985 & 1986 THIN PAVEMENT SURFACE TREATMENT PROJECTS

	Asphalt Concrete	Chip Seal	Oil Mat	Recycled A.C.	Blade Patch	Total
Region 1	7	6	0	0	2	15
Region 2	6	5	0	0	0	11
Region 3	8	4	0	0	0	12
Region 4	5	6	0	13	0	24
Region 5	5	10	10	2	0	27
TOTAL	31	31	10	15	2	89

5. 1984 ASPHALT CONCRETE PROJECTS

Thickness Type of Mix	.75"	1.5"	2"	Total
B	0	3	0	3
C	0	4	4	8
E (with seal)	5	0	0	5
Emulsified	0	0	1	1
TOTAL	5	7	5	17

6. 1985 ASPHALT CONCRETE PROJECTS

Thickness Type of Mix	.75"	1.5"	2"	Total
B	0	2	0	2
C	0	6	1	7
E (with seal)	1	0	0	1
F (with seal)	0	3	0	3
Emulsified	0	1	0	1
TOTAL	1	12	1	14

7. 1984 & 1985 ASPHALT CONCRETE PROJECTS

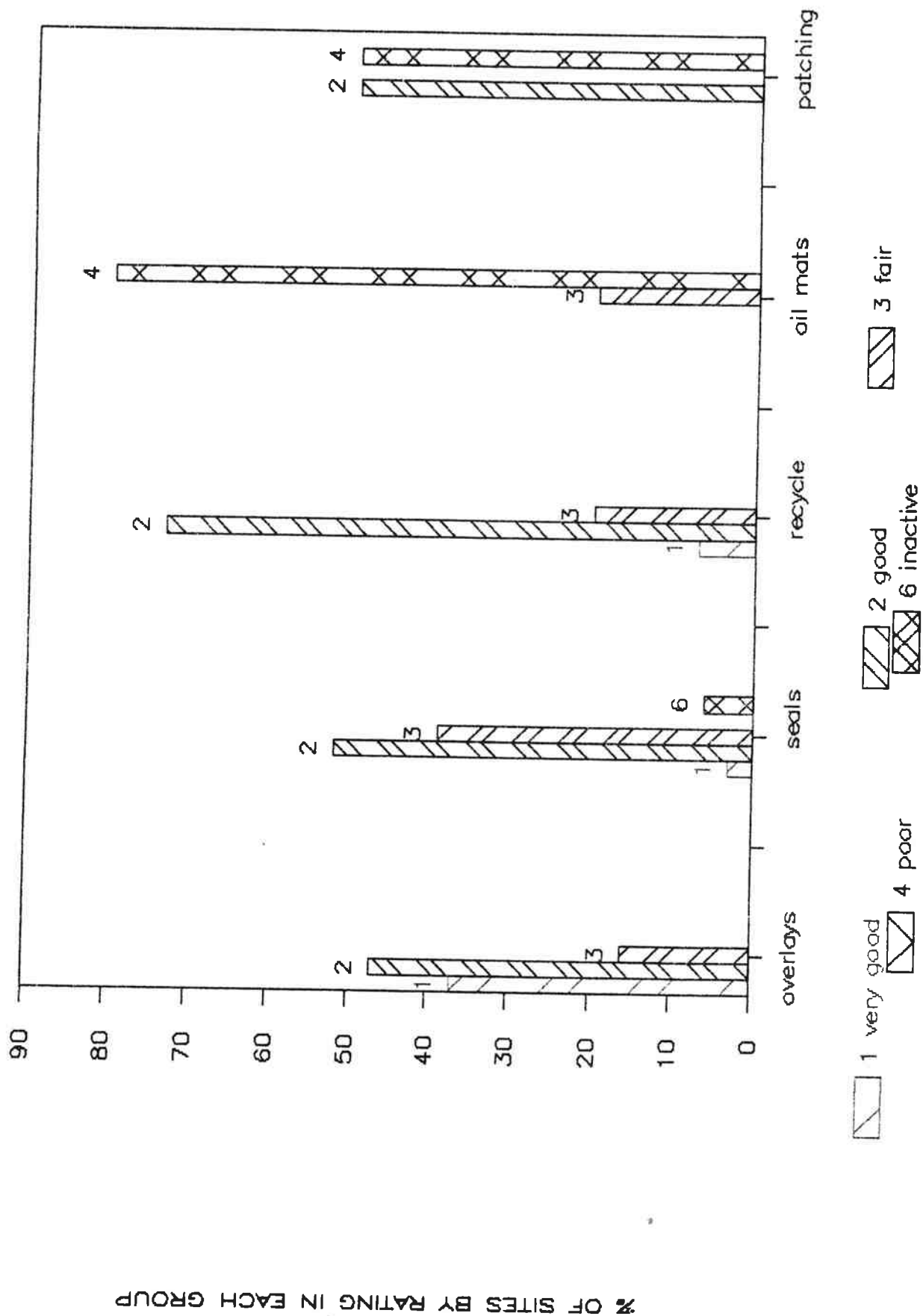
Thickness Type of Mix	.75"	1.5"	2"	Total
B	0	5	0	5
C	0	10	5	15
E (with seal)	6	0	0	6
F (with seal)	0	3	0	3
Emulsified	0	1	1	2
TOTAL	6	19	6	31

8. CHIP SEAL PROJECTS

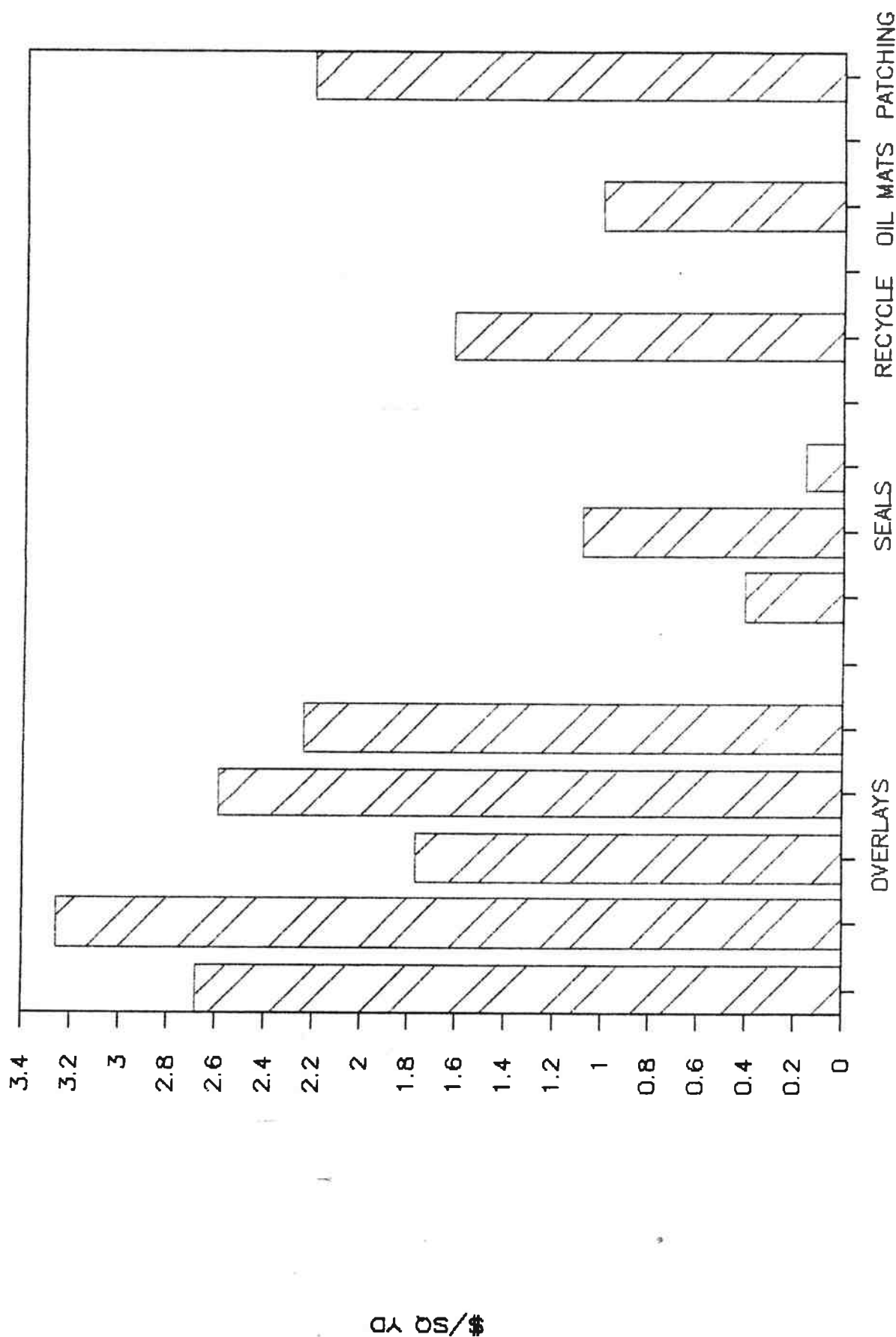
Year	Polymer Modified Emulsified Asphalt	Emulsified Asphalt	Total
1984	6	10	16
1985	9	6	15
TOTAL	15	15	31

A P P E N D I X "C"

RATING OF TEST SITES 1986



AVERAGE COSTS OF SURFACE TREATMENTS



NOTE: Overlays are (from left to right) B, C, E, F & Emulsified A.C.'s.

Seals are (from left to right) Chip Seals, Polymer Modified Chip Seals & Sand Seals.